

Variations in Sleep and Performance by Duty Start Time in Short Haul Operations

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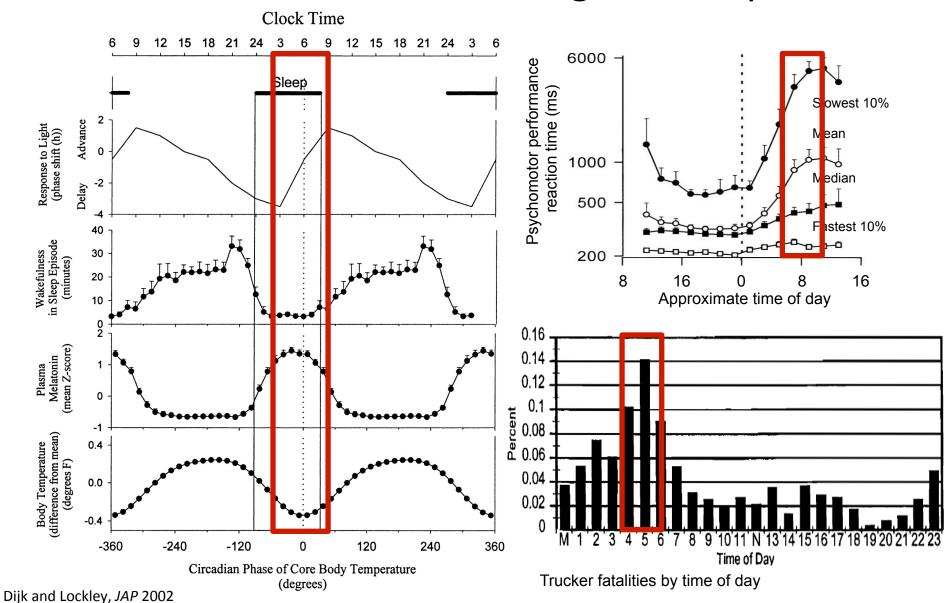
Fatigue Countermeasures Laboratory
NASA Ames Research Center

Short Haul Pilots can Experience Circadian Misalignment

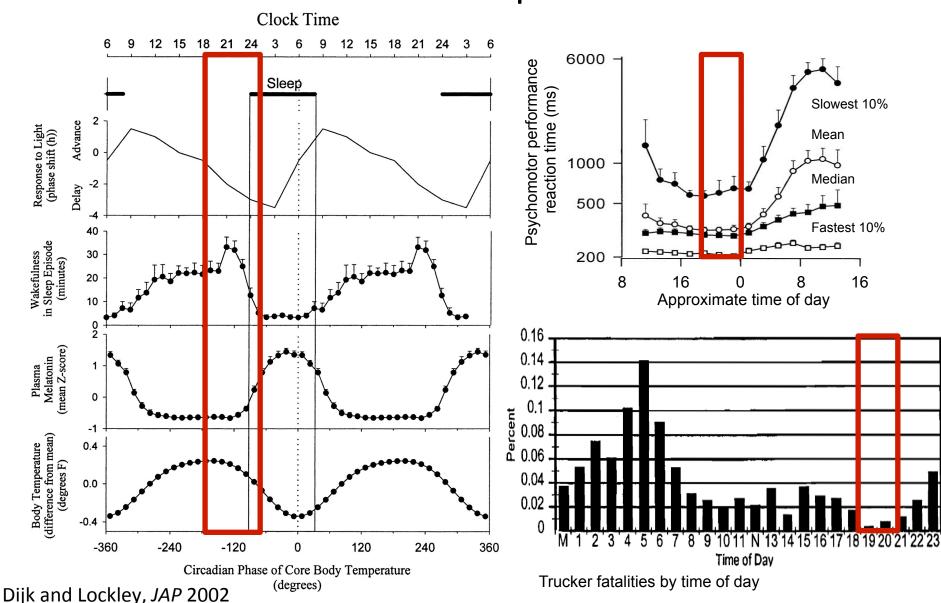
Clock Time 9 12 15 18 21 24 12 15 18 21 24 6000 Psychomotor performance Sleep reaction time (ms) Slowest 10% Advance Mean 1000 Median Delay 500 Fastest 10% 40 Wakefulness in Sleep Episode (minutes) 30 200 20 16 16 Approximate time of day 10 0.16 Plasma Melatonin (mean Z-score) 0.14 0.12 0.1 80.0 Percent 80.0 90.0 Body Temperature (difference from mean) (degrees F) 0.4 0.0 -360 -120 0 120 -240 240 360 Time of Day Circadian Phase of Core Body Temperature Trucker fatalities by time of day (degrees) Dijk and Lockley, JAP 2002

Circadian Nadir =

Poorest Performance and Highest Sleep Drive



Circadian Wake Maintenance Zone = Lowest Sleep Drive



Short Haul Aviation Study

- Systematic evaluation of schedule types
 - Baseline, early, evening, night schedules
 - Assessment during duty days and days off
- Outcomes
 - Hassle factors
 - PVT on iPod
 - Actigraphy
 - Sleep logs
 - Sleepiness scales, countermeasure logs
 - Urine collection for melatonin assessment
- Data Mining
 - Operational outcomes
 - Correlations with fatigue measures





n = 44 study

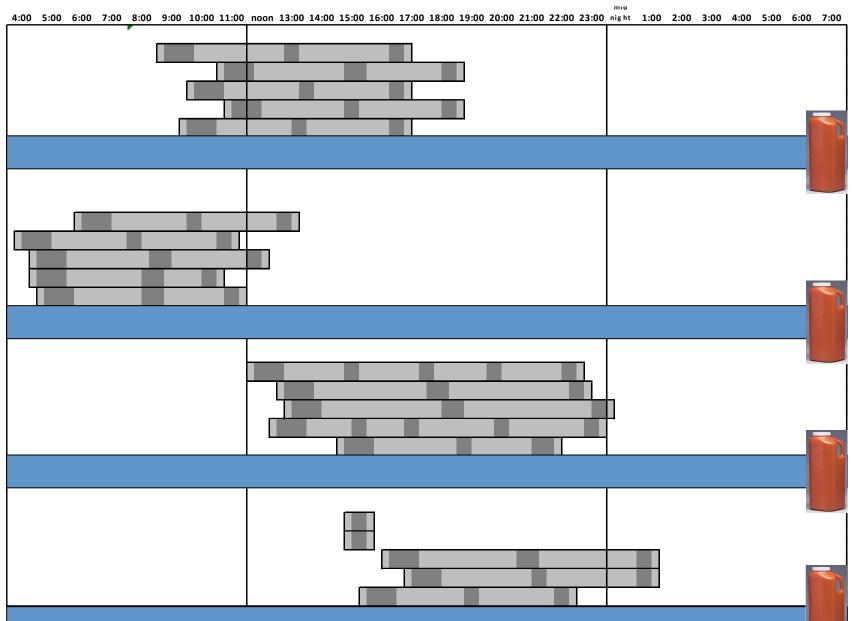
n = 13 urine collection



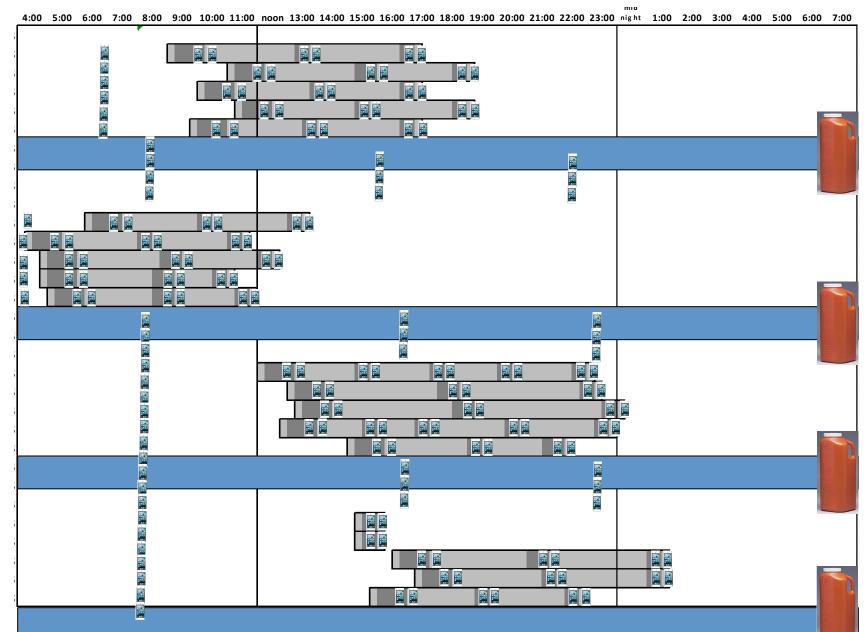
Study Protocol

4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00 noon 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 night 1:00 2:00 3:00 4:00 5:00 6:00 7:00

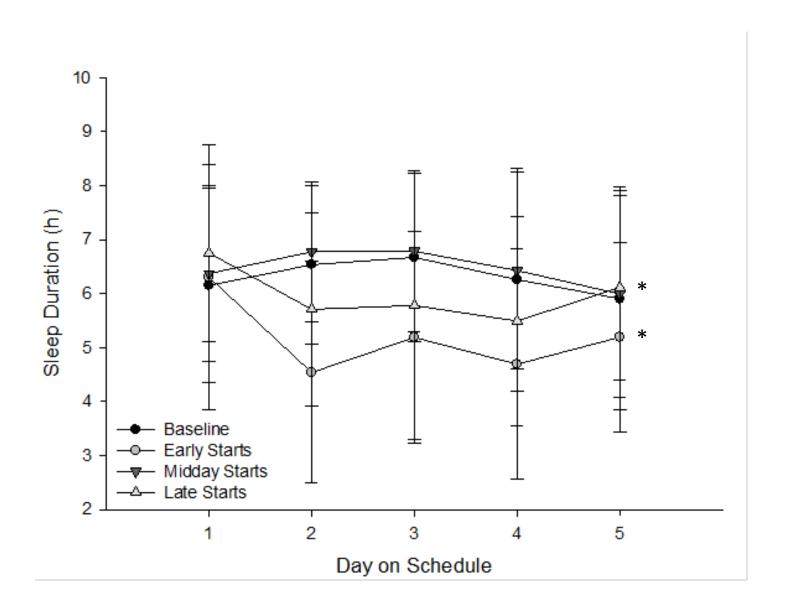
Study Protocol



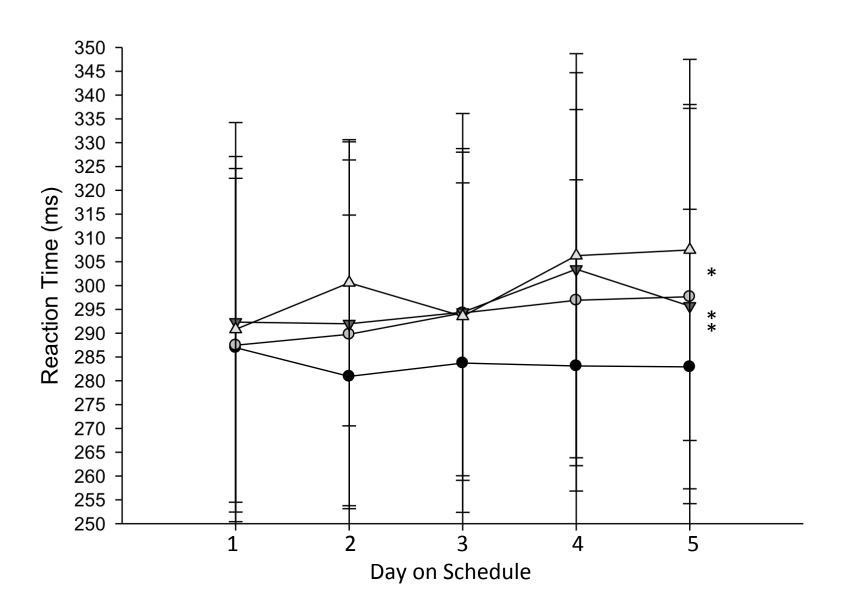
Study Protocol



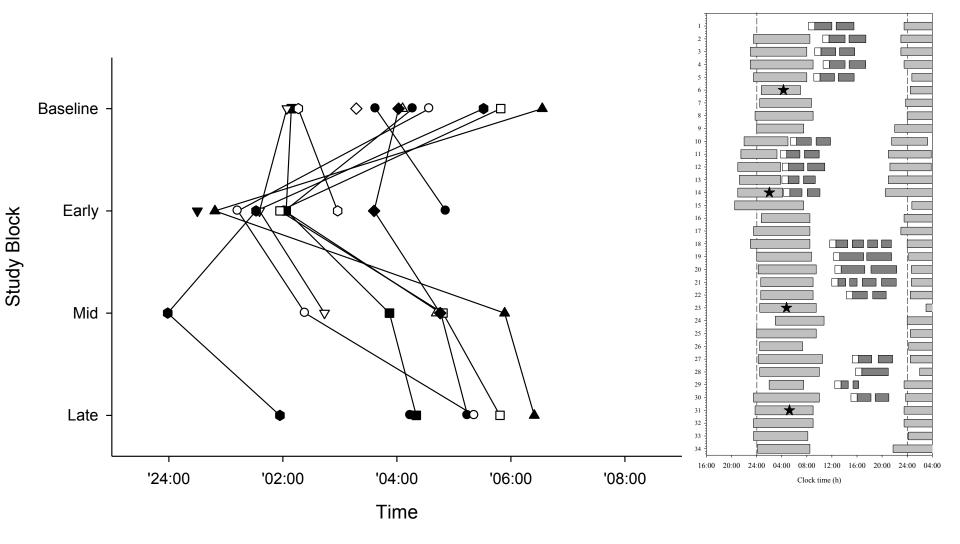
Sleep Outcomes



Performance Varied by Duty Start Time



Circadian Phase Shifts

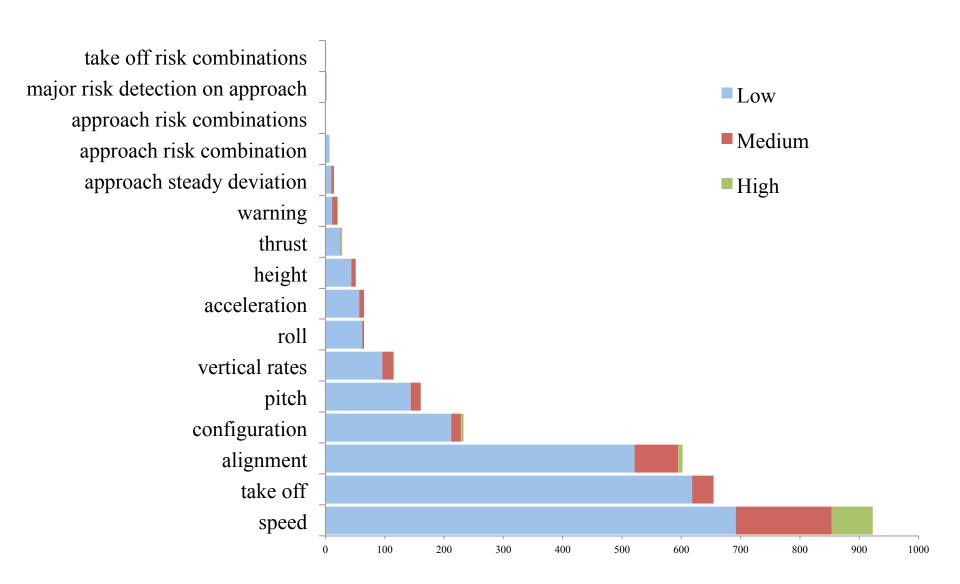


Aircraft Performance Exceedance and Anomaly Detection

- n = 1644 flights
- Flights coincided with collection of human performance data

Severity Type	Min	Max	Sum	M	SD
Low	0	8	2499	2.19	1.64
Medium	0	4	358	.31	.60
High	0	2	87	.08	.29

Categories of Events



Human Performance v. Aircraft Performance Measures

	N (flights)	Mean PVT	Mean exceedances
Baseline	204	212.02(29.72)	1.91(1.91)
Early duty	207	222.31(34.32)*	2.73(2.04)**
Mid duty	254	221.62(33.59)*	2.77(1.84)**
Late duty	139	227.48(35.16)**	2.71(2.10)*

Exeedances by Type and Duty Schedule

		Se	Overall		
	n	Low	Medium	High	
Baseline	143	1.73(1.78)	.18(.47)	.08(.27)	1.99(1.99)
Early duty	196	2.31(1.79)**	.31(.61)*	.12(.9)	2.74(2.10)**
Midday duty	238	2.44(1.56)*	.30(.61)	.07(.29)	2.81(1.85)*
Late duty	138	2.27(1.65)	.44(.73)	.04(.24)	2.73(2.07)

Acknowledgements

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Volunteer participants